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REASONING BEYOND PREDICTIVE VALIDITY: THE ROLE OF PLAUSIBILITY IN DECISION-SUPPORTING SOCIAL SIMULATION

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ABSTRACT

Practical and philosophical arguments speak against predictability in social systems, and consequently against the predictive validity of social simulations. This deficit is tolerable for description, exploration, and theory construction but serious for all kinds of decision support. The value of plausibility, however, as the most obvious substitute for predictive validity, is disputed for good reasons: it lacks the solid grounds of objectivity. Hence, on the one hand, plausibility seems to be in contradiction to scientific inquiry in general. On the other hand, plausibility is paramount and ubiquitous in practical decision making. The article redefines plausibility in order to render it more precise than colloquial usage. Based on the experiences with military applications different lines of reasoning with plausible trajectories based on computer simulation are analyzed. It is argued that the rationale behind such reasoning is often substantially stronger than a mere subjective expert opinion can be.

1 INTRODUCTION

The subject of this article can be sketched by three citations, designating a challenge, a skepticism, and a (defiant) objection:

1. "Simulations models of complex social systems are, a priori and in general, not a trustworthy representation of the future of their real world equivalent (Batty and Torrens 2005)."
2. "A number of simulation professionals, including myself, believe that it is impossible to verify and validate large-scale simulation models to a reasonable confidence level (Sargent 2000)."
3. "If you do not trust a carefully executed simulation, you probably have less reason to trust anything else, including the way you currently make decisions (Johnson 2001)."

For a couple of reasons it seems impossible to understand human societies as thoroughly as technical devices or physical systems (which have their own limits: see Konikov and Bredehoeft (1992), Dessai et al. (2009) and Ruphy (2011)). Among these reasons are

- self-reflection of humans (an ability that transcends all formal (Goedel 1931), technical, and natural systems), enabling for example
- deliberate counteraction against predictions (for a historical example see (Merton 1936, 904)),
- ignorance of initial system conditions (What is the exact current state of a social system?),
- surprising technical innovations with unpredictable effects on society (Rosenberg 1993),
- and inscrutable constructions of own "realities" in human minds (von Glasersfeld 1995).

These limitations are in evidence with respect to prediction (von Hayek 1989, Hemez 2004, Kristof 2006, Meadows, Randers, and Meadows 2004). Consequently, simulation runs of social phenomena can seldom

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be validated in the strict sense of predictions that are regularly corroborated by empirically data. This calamity is known for decades (Hermann 1967, Churchman 1973), and has also been addressed intensively in Operations Research (Landry and Oral 1993). The challenge is currently well known in the context of HSCB (human, social, cultural, and behavioral) modeling ((Tolk 2009, Tolk et al. 2010)), and belongs to the broader topic of epistemology (Tolk et al. 2013). The bottom line is that very often simulation runs are only *plausible* in the sense of *possible but not necessary* from an expert point of view. However, plausibility, as a foundation for scientific reasoning, has been attacked for good reasons: the concept seems to lack all solid grounds of objectivity. Consequentially, plausibility has been criticized as a justification for social simulations. It has been argued that in order to contribute to science, and to surpass the level of arbitrary models, social simulations have to provide strong evidence of empiric concordance with the corresponding real world system. This article tries to relax this categorical view by presenting lines of reasoning which allow the use of plausibility in practical decision making. The central question, which has concerned the author for decades (Hofmann 2002a, Hofmann 2002b, Hofmann and Hahn 2007, Hofmann 2013) is: *What are objective, rational lines of argumentation for the use of merely plausible computer simulation runs for decision support in social systems?*

The paper tries to answer this question from the perspective and experience of a military computer simulation specialists. The military domain is well suited for the investigation of the question for a couple of reasons:

- Reasoning with visualizations of plausible courses of action has a long tradition among military decision makers. In fact, mental simulation of plausible courses of action has always been and still is one of the cornerstones of military reasoning.
- Although physical and technical processes of weapon systems play a decisive role in actual combat, almost all modern military conflicts are dominated by HSCB aspects. The inclusion of these aspects is therefore vital for decision making.
- Most of the arguments used in this paper can be traced back to three articles (Helmer and Rescher 1959, Hodges 1991, Bankes 1993), which have written from a military operations research background (RAND scientists, for a recent summary see (Davis 2012)).
- Since computer simulations are ubiquitous in military training, decision makers are used to the method, its advantages, and drawbacks.

2 SOME ESSENTIAL DIFFERENCES BETWEEN SCIENCE AND DECISION MAKING

Edmonds (2010) has criticized with much emphasis the use of empirically uncorroborated models in social science. He argues in detail why such *floating models* (Wartofsky 1979) or *thin simulations* (Kliemt 1996), which "might be justified vaguely with reference to some phenomena of interest, use many assumptions that are justified solely in terms of their surface plausibility to the modeler, that are fitted loosely to some known data for outcomes", cannot contribute to scientific progress in sociology. Although his reasoning might be exaggerated in some aspects concerning the value of "explorative" models for any kind of science, one is inclined to agree that science cannot be founded on the "surface plausibility" of models that instantiate personal opinions in formal systems. However, the overwhelming majority of decisions which have to be taken from the persons in charge in social systems cannot be based on hard scientific facts. This is basically what Kant described concisely in his aphorism: "The necessity to decide exceeds the possibility to comprehend (attributed to Immanuel Kant, 1724 - 1804)." The timelessness of this proposition becomes evident reading Angela Merkel's contribution to a book on policy advice with the same title in German (Merkel 2004). The simple message of the aphorism is that we often simply do not know enough to be sure about many inevitable decisions. Despite this calamity one has to ask whether practical decision making beyond scientifically proven predictive validity can be supported by justified reasoning, for example from computer simulation models. In order to do so, some essential differences between science and practical decision making have to be kept in mind. With respect to the subject of this paper the most important aspects of practical decision making are presumably

- a definite point in time when a certain decision has to be taken,
- a limited group of persons, which have to decide on the sole basis of their current knowledge and interests (decision maker and his staff of "experts"),
- and a very specific, often unique, situation that immediately affects the stakeholders.

In contrast, (fundamental) science is

- an infinite progress of improving our understanding of the world,
- at least in principle, not restricted to any social group,
- concerned about general rules guiding situations under ceteris paribus conditions.

In this paper, we will argue that it is counterproductive to apply the rigorous demands of science on the validity of its models to practical decision making.

3 BASIC DEFINITIONS

Figure 1 shows a "standard view" of the model building process with some terms and relations used in this article. A *trajectory* is a specific course of selected output parameters from a single simulation run. It is taken as a potential representation of a *scenario* (a course of action) in the referent. The concordance of trajectories and scenarios is, a priori, unclear for predictive purposes.

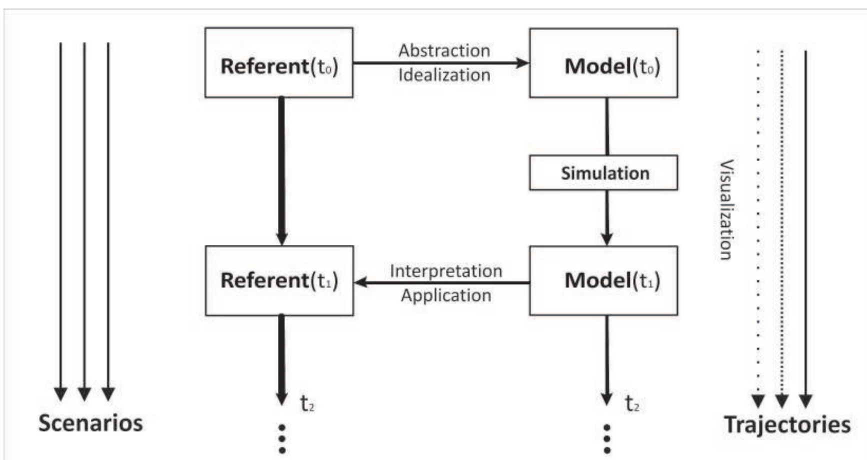

Figure 1: Scenarios and trajectories in a standard model building framework.

Although a plethora of different colloquial meanings of plausibility exist the term is essentially based on the subjective belief (of experts) into a statement about a phenomenon. In the following, we restrict the use of the adjective *plausible* to visualizations of simulation trajectories representing future real world scenarios. With other words, after visualization and interpretation a trajectory is considered to describe a potential future scenario. Plausibility in that sense is defined by

1. a subjective degree of belief into a trajectory, based on individual experience or expertise, which is impossible to transfer into consistent precise probability values,
2. a lack of objective, undeniable facts or indisputable logical derivation underpinning the belief, but also
3. a current lack of empirical evidence to falsify the trajectory,

4. an immanent inclusion of other plausible but contradicting trajectories (the belief in one trajectory does not exclude belief in at least one other irreconcilable trajectory), and
5. a partially ordered relation: A trajectory is said to be more or less likely than another. Partially implies that there may also exist some incomparable statements: The expert simply does not know which of two statements is more likely or if both are equally likely.

It is essential to realize that "plausible" in that sense is not simply a weak replacement of the term "valid" as it is used in the modeling and simulation community. Plausible in the restricted sense of this article is a term only applicable on the visualizations of simulation trajectories representing future real world scenarios which are assessed from experts by what is called face validation. In this article, the term "plausible" is neither applied on the models themselves nor on the assumptions used for the modeling (plausible models, plausible assumptions). However, a valid trajectory differs decisively from a plausible one: A *deterministically valid trajectory* is an exact prediction of a corresponding scenario in the future (e.g. short term prediction of the positions of planets). The probability attributed to a *stochastically valid trajectory* is confirmed by frequency measures of iterative successful prediction under ceteris paribus conditions (e.g. weather forecasts). A mere plausible trajectory lacks the corroboration of observable facts or stringent logical derivation from similar past cases. Consequently, a plausible trajectory is epistemologically equal to an unproven hypothesis (at least from a positivist's perspective).

4 REASONING WITH PLAUSIBLE SCENARIOS IN MILITARY DECISION MAKING

Throughout the millennia military leaders have tried to mentally simulate the different courses of action that might evolve from a plan or decision. To these decision makers it has been clear that their mental simulations could not encompass the totality of possible courses of action in reality (Beyerchen 1992). Consequently, a set of scenarios regarded to be plausible (in a similar sense as defined in the introduction for trajectories) has always been the foundation of military decision making ("*decision making under plausibility*"). An optimistic leader has tried to realize the most promising scenario; a pessimistic leader has tried to prevent disastrous ones. In modern times, many structured, rational approaches have added to such simple reasoning but still, all these methods are founded on guesswork about the enemy's capabilities, determination and intentions, and the effects of human factors on the battlefield. To most leaders it has also been clear, that due to these fundamental uncertainties unexpected events and scenarios are unavoidable. Hence, the basis of military decision making regardless of the special method applied for the comparison of options has been and still is an incomplete set of plausible future scenarios. How do military decision makers reason with such scenarios, today? Beside the timeless worst case / best case approaches many other heuristics are used:

- The origin of institutionalized *war gaming* dates back to emerging Prussia and its General Staff in the 19th century, and it can be described as an interactively play of different courses of action. It is based on the idea that uncertainty about the current plan can be reduced by visualizations and further evaluation of plausible events and scenarios.
- If enough time is available military plans are elaborated with great detail. Sometimes the staff members start to believe that the plan will be executed as written down. This is, almost ever, an illusion. The overwhelming majority of military plans have to be modified immediately after action starts. It is therefore essential, to train decision makers and staff members to expect that the meticulously planned course of action will not happen ("*contingency planning*"). In that context the visualization of other plausible courses of action has great power of persuasion.
- The term *weak point analysis* does not specify a single well defined operational analysis methodology but a general approach for the critical rethinking of own plans or projects. The crucial idea is to identify courses of action that might endanger the plan or project. Weak point analysis can be done mentally by the decision maker himself or by the help of external experts, or with models

that represent the referent in which the decision has to be taken. The latter approach is, in general, performed with analog simulation (mission rehearsal on a tactical sand table, for example) or computer simulations.

- *Assumption-based planning* (ABP) is a method that helps military decision makers to deal with uncertainty. It is used to identify critical (implicit or hidden) assumptions in plans, to test these assumptions, and to accommodate unexpected outcomes (Dewar et al. 2005). Computer simulation can help to detect such hidden assumptions by generating unexpected trajectories that correspond to plausible scenarios.

Precisely, all these lines of reasoning are based on the *currently discerned part of plausible scenarios*. The zone of plausible scenarios in itself is a theoretic construction: It comprises every scenario that a specific team of experts would assess as plausible *if they knew about it*. This distinction reflects the different complexity between constructing a plausible scenario and verifying a given scenario as plausible. Moreover, the zone of plausible scenarios has to be distinguished from a second completely theoretic construction, the zone of all valid scenarios, which describe *everything that can actually happen*. The plurality of the concept assumes that despite perfect knowledge about initial conditions the future is not determined. A lot of different scenarios are still realizable. The working assumption behind this concept is that social systems are governed by currently unforeseeable individual decisions and random effects. Consequently, the future is not determined in a single path but resembles an *imagined* tree with branches created by known and unknown options in combination with the freewill of decision makers, and random events with (in general) unknown probabilities. (see figure 2).

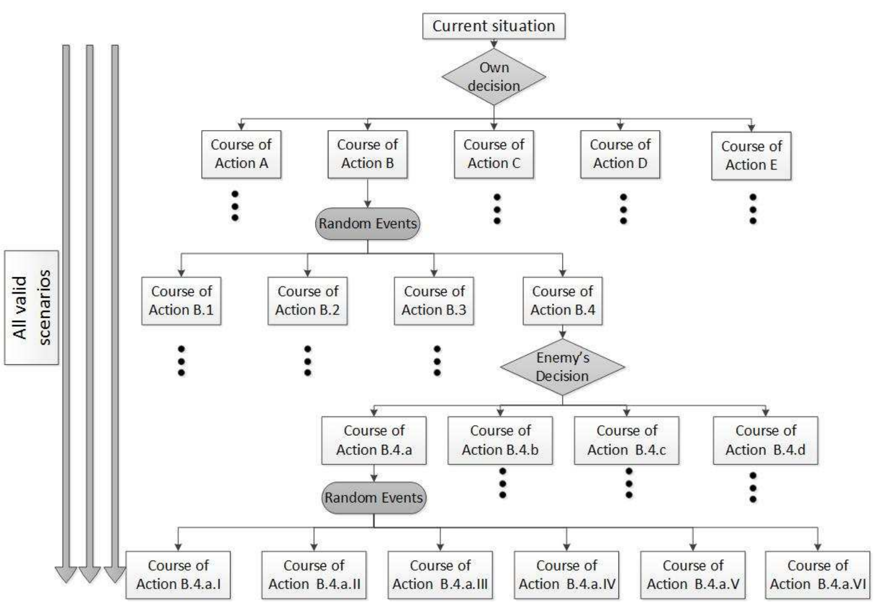

Figure 2: A hypothetical completely valid scenario tree representing all possible scenarios

Decision theorists have tried to advocate the completeness of such trees ("decision trees"), in which all options and all stochastic events are explicitly modeled. However, at least in actual combat, one has to admit that the creation of a complete tree of possible scenarios (paths in the future) is beyond the limits of human cognition ("bounded rationality", Simon (1982)). Nevertheless, a *hypothetical, optimally informed decision maker* would have to consider such complete trees representing all possible (and therefore, on the basis of current knowledge, all valid) scenarios. A scenario in the tree visualization is a path from the root (current situation) to a leaf. Note that even a complete and valid scenario tree cannot assure an optimal decision. Since the probabilities of the random events are (in general) unknown the optimally informed decision maker would still face a decision situation under strict uncertainty (Knight 1921). In such situations no single optimal decision rule exists only heuristic criteria, like, for example, Wald's, Hurwicz's, Minimax, Savage's and Laplace's criterion (Pataki 1995). However, all these criteria presuppose complete, consistent decision matrices (or trees) (representing "small worlds" (Savage 1951)). Therefore, ideally, the currently discerned part of the zone of plausible scenarios should be identical to the zone of all valid scenarios. No potential scenario would escape the awareness of the decision maker. However, in reality, the complete scenario tree is inaccessible for the decision maker. According to this perspective, some of the possible courses of action in figure 2 will be ignored (all crosses in figure 3). In addition, the staffs can imagine trajectories (by mental simulation, for example) that do not correspond to any valid scenario (rhombuses in figure 3).

It is even realistic to assume that there are some valid scenarios that would not be considered plausible from the staff in advance even if disclosed to the expert team (black crosses in figure 3). History is full of examples for such ignorance. In addition, gray crosses indicate scenarios that are currently ignored but would be considered plausible from the expert team if disclosed to them (for example by espionage). In contrast to figure 2 the decision tree visualization in figure 3 is not hypothetical; it is, in fact, the foundation of almost all military decision making. In realistic settings experts make errors: They assess possible scenarios as implausible (black crosses), they ignore possible scenarios (gray crosses), and they wrongly believe in the plausibility of impossible scenarios (rhombuses).

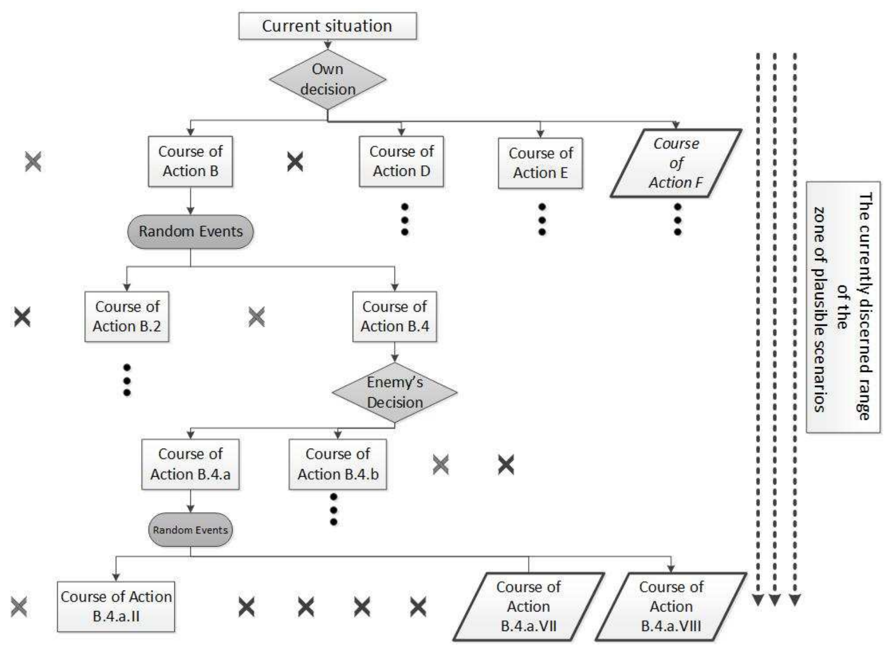

Figure 3: A realistic scenario tree visualizing the currently discerned range of the zone of plausible scenarios

Consequently, the military decision maker has to be aware that his decision is based on a set of future scenarios which is incomplete, and most probably partially wrong. Before discussing the role of plausible computer simulation trajectories in decision support it helps to abstract a little further using simple Venn diagrams. Figure 4 shows the difference between the hypothetical setting of a perfectly informed decision maker and a realistic setting in this simplified visualization. Looking at this illustration it is absolutely essential to realize that the zone of valid scenarios is supposed to be unknowable. The top diagram in figure 5 illustrates the position of black crosses (unknown scenarios), gray crosses (currently not perceived plausible scenarios), and rhombuses (misleading unrealistic scenarios) within the Venn-diagram.

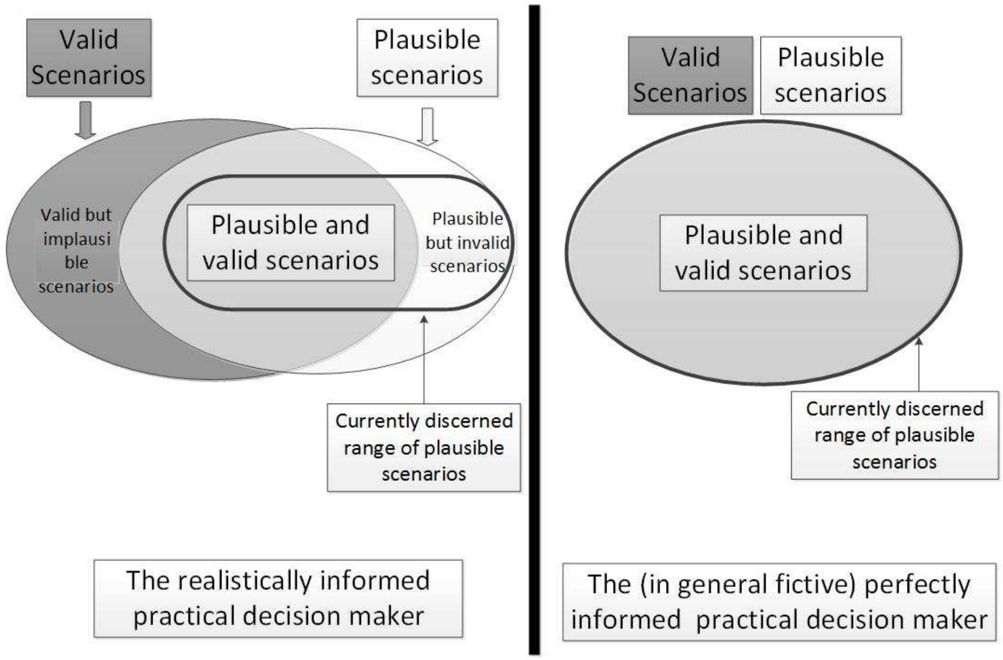

Figure 4: Venn diagrams showing the difference between realistically and perfectly informed decision makers

In summary, almost every military decision during combat is taken on the basis of an imperfect, currently discerned range of plausible scenarios. The ideal on the right of figure 4 is a rare exception. Hence, a central question for decision support is, how to reduce the number of ignored possible and wrongly assumed plausible scenarios.

5 SUPPORTING MILITARY DECISION MAKING WITH PLAUSIBLE TRAJECTORIES

Within the framework presented so far, it is possible to visualize in principle how plausible simulation trajectories can support military decision making. The first step is to interpret the visualization of simulation trajectories as plausible scenarios as shown in figure 1. In military practice, this is generally a selective process: The members of the expert team (staff) check the visualizations, and disapprove completely implausible trajectories (subject to errors, too!). The remaining trajectories are considered to represent (more or less) plausible scenarios in the referent. It is evident that the plausibility of a simulation trajectory is increased if the basic physical aspects of elementary processes underlying military combat (movement, attrition, reconnaissance, transport, etc.) have been empirically validated in the simulation model. However, validation of micro processes can never guarantee predictive validity for the social macro phenomena (here: combat).

In the setting of classical simulation-based decision making (based on "valid" simulations) one would use a simulation trajectory representing a scenario within the currently discerned range of plausible scenarios as a confirmation. This reasoning is extremely weak if the simulation model lacks predictive validity. Therefore, when reasoning under plausibility it is better to strive only toward a reduction of the potential errors in the currently discerned range of plausible scenarios. What one is looking for is visualized in the three lower diagrams of figure 5: The hope is that simulation trajectories *disclose* hidden plausible scenarios, rebut invalid scenarios (the trajectory is *confutative*), and *explore* into hitherto ignored valid regions.

From the three lines of reasoning behind these applications of plausible trajectories disclosing simulation is most convincing. The simulation only increases the currently discerned range of plausible scenarios into

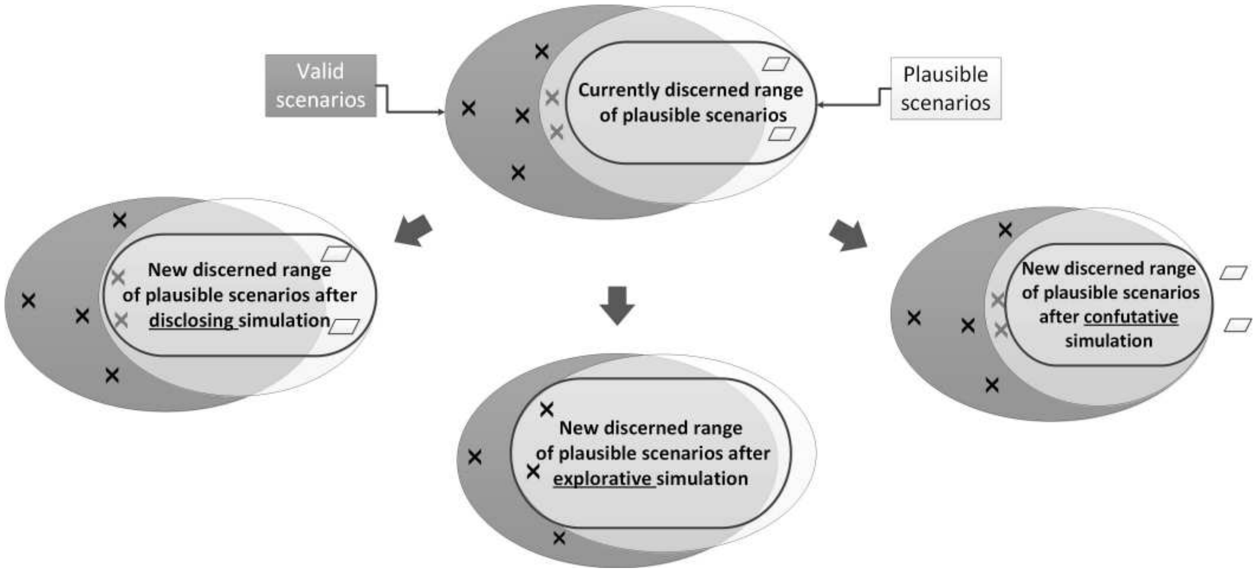

Figure 5: Changing the range of currently discerned plausible scenarios by computer simulation

the zone of valid and plausible scenarios. Epistemically, reasoning with disclosed plausible scenarios (based on simulation trajectories) is relatively easy to defend. The simulation has rendered implicit knowledge explicit. Or, to use a more technical argument from computer science, it is much easier to verify than to construct. In addition, the random generators used to model uncertainty about elementary stochastic processes guarantee that the simulation output is not a trivial function of the input and the conceptual model. A simulation trajectory of a complex combat simulation model can therefore indeed disclose plausible scenarios that are *new* to the decision maker.

There is also a simple, simulation based approach for dealing with invalid scenarios (the rhombuses in figure 3), the so called *a fortiori argument*. This argument, as introduced into policy analysis by Hodges (1991), works like this: "If condition X were true, then policy A would be preferable to the other candidates: But the actual situation deviates from X in ways that favor A even more. Thus a fortiori, A is preferable." This reasoning is easily adaptable on simulation based plausible scenarios: If a scenario is based on assumptions that uniquely favor one side, then negative simulation results for this side indicate that reality presumably will be even worse. If we run a simulation model built on optimistic assumptions only, and are nevertheless not able to produce a trajectory that represents the scenario indicated by a rhombus, the expert team might be disposed to rethink its plausibility assessment (right diagram in figure 5). It is obvious, that the validation of some of the micro processes can play an important role in this reasoning. Physical speed limits of vehicles in difficult terrain, for example, may falsify the feasibility of scenarios.

In order to address the errors indicated by the black crosses, one has to increase the zone of plausibility itself. Such an adjustment (lower diagram in figure 5) is much harder to achieve than a change of the currently discerned range within the zone of plausible scenarios. The simulation run must be very convincing in order to make the expert team change its evaluation of plausible versus implausible scenarios, since such a shift implies a self-critical reassessment based on mere exploration. The most prominent additional methods of simulation-based exploration in military decision making are data farming and simulation-based war gaming. Explorative data farming (Brandstein and Horne 1998, Hofmann 2013) is a universal method which is of special interest at the beginning of decision making process when the relation between the valid and the plausible zone of scenarios is completely unclear. Explorative data farming expands the plausibility zone, sometimes even far beyond the range of validity. Statistical data farming therefore first expands the zone in order to condense it into more restrictive stochastic measures. This method seems very satisfying, since it can yield quantitative results. However, from an epistemic point of view, it is difficult to defend this procedure since the statistical operations do not work on valid scenarios (facts) but on plausible ones (hypothesis), which might be far off reality. Moreover, in order to process plausible scenarios statistically, it is necessary to assume a probability distribution over the single scenarios. Without further information this is, generally, a Laplacian probability space (assuming equal probabilities), which can hardly be justified on solid grounds. The use of statistics therefore often obscures the hypothetical character of reasoning with plausible scenario in military applications. Shaky statistics are then taken as "hard facts" underpinning a decision. This is a very dangerous line of reasoning since the calibration of simulation parameters allows to "fine tune" results in a preferred direction. One can even argue that this problem is fostered by the current urge to validate computer simulations quantitatively. Presenting statistics can help to create the illusion of validity.

Computer supported wargaming (Hofmann and Lehmann 2007, Hofmann and Junge 2008), finally, is a way of pushing in a focused manner at the rim of the currently discerned range of plausible scenarios. The major advantage of computer simulation during war gaming is better traceability via automatic documentation and powerful scalable visualization. The value of the method as a explorative tool is that it drives the planner, or decision maker, to think critically and in great detail about not only his own plan, but the enemys plan and the environment as well. The simulation of courses of action within a war game exposes gaps and conflicts in information and weak assumptions, and forces him to address those incongruities through contingency planning (increasing the zone of plausibility). Unfortunately, we do not know in advance whether this pushing aims to the right direction, which leads us to the limits of the whole approach.

6 THE CENTRAL CRITIQUE

Validity is oriented on the ideal of objective truth. Plausibility, in contrast, can only reflect subjective expertise. Such expertise has a long history of fatal errors. We simply do not have a guarantee that the visualization of a computer simulation trajectory which is considered plausible from an expert team actually corresponds to a valid scenario. It may only correspond do the misconceptions and the tunnel vision of those "experts" (Tetlock 2005, Gardner 2011). Therefore, we do not and probably cannot know in advance how far the expert opinion is off the valid region. If the experts change their assessment on the basis of explorative trajectories they can shift the plausibility zone into the wrong direction (see figure 6), reducing the overlapping area of plausible and valid scenarios, or, at least, reducing the ratio of this decisive area with respect to the currently discerned range of plausible scenarios. With other words, the percentage of invalid scenarios in our basis for decision making increases.

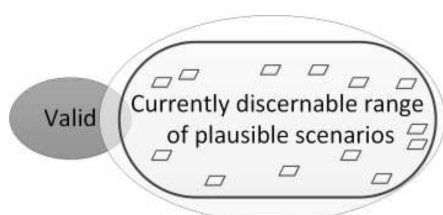

Figure 6: Wrong direction of the shift of the plausibility space

This calamity seems to undermine the reasoning with plausibility, since we are back at the beginning of the paper. However, we think that there are some fundamental differences between expert opinion only and experts being supported by computer simulation.

7 REASONS FOR OPTIMISM

First of all, the simulation model is, in general, not developed by the expert group using it for decision making. In military practice, the model has, most likely, been designed, coded and evaluated by a different group of experts. We can assume that they have made their assessment on their own plausibility perspective.

Hence, the simulation model incorporates independent expertise that might challenge the view of the expert team counseling the decision maker. In addition, military simulation models, which have been used for decades, often incorporate the knowledge of specialists (engineers, meteorologists, weapon effects specialists etc.) not available in the current team. Thus, a computer simulation run can be seen as an independent, well-informed additional expert view. Moreover, it is possible to restrict many of the elementary (micro) processes of combat (movement, attrition, reconnaissance, transport, technical communication etc.) in computer models to physically possible ranges. Unfolding such models by simulation often reveals that some plausible scenarios are outside the zone of valid scenarios, for reasons of physical impossibility. This does not mean to argue on the basis of valid scenarios: Restricting scenarios by physical impossibility is no guarantee for predictive validity. In social systems such a "zoning" is much too coarse. Therefore, even for the scenarios generated by algorithms representing physically possible processes, expert judgment about the plausibility of the resulting trajectories is indispensable: The interaction of algorithms for micro processes produces practical impossibilities on the macro level which are hard to detect automatically but trivial for an expert. Thus, it is the combination of "valid micro" processes and plausible visualizations of macro trajectories representing scenarios that generates an important benefit for decision making. In addition, the usual setting of theoretical decision making is based on the idea of risk. Risk, however, assumes that detrimental events and their probabilities are known. We are talking here about genuine ignorance. Consequently, strictly valid lines of reasoning are insufficient for success. This has been proven by military history, which is full of, admittedly anecdotal, examples for decision makers who had to decide on extremely limited information, and who have found ingenious solutions for this problem. Often the visual display of plausible scenarios on sand tables and maps has triggered the decisive course of action. Today, computer simulations replace these analogous representations digitally. The majority of the lines of reasoning presented in section 4 and 5 are methods of critical rethinking. They are not intended for strong affirmation but for skepticism. One of the main functions of all reasoning with plausible scenarios in general, and simulation based scenarios, in particular, is to generate humility with respect to the power of exact planning in social systems. (Embracing the ideas of "humble social science modeling" from Davis (2009)). Taking all these factors together, it seems quite reasonable to be optimistic that the use of visualizations of plausible computer simulation trajectories can improve practical decision making, not only in the military domain despite serious limits with respect to epistemic certainty.

8 SUMMARY AND CONCLUSION

Mere plausibility has a rather bad reputation in science. Since it is founded on subjective expert opinion, plausibility, as a generic concept of quality assurance, rests on uncorroborated beliefs. However, a plethora of challenging practical decision problems exists for which we cannot generate valid trajectories into the future. Consequently, common human decision making is often grounded on plausibility as the only available replacement for validity. In this paper a pertinent definition of a plausible visualization of a computer generated simulation trajectory has been given. It has been illustrated how plausible scenarios are used for decision making in the military domain. In the central part of the article it has been tried to extricate the epistemic foundation underlying the use of plausibility with respect to decision making, highlighting as well the limits of the approach as reasons for optimism. Three different modes of arguing with plausible simulation-based scenarios have been identified: disclosing, confutative, and explorative simulation, which are based on different lines of reasoning. The main results of the article are: Firstly, that plausibility is an indispensable means of practical decision making under uncertainty and ignorance. Secondly, plausible simulation trajectories are powerful tools of supporting critical thinking, although they cannot guarantee better decisions, and it is difficult to use them for affirmative ((Bankes 1993, 435) used the term *consolidative*) purposes. Thirdly, computer simulation offers important advantages in comparison with reasoning based on expert opinion only. Fourthly, the greatest benefits of reasoning with (macro level) plausibility are achievable on the basis of (partially) micro level validity. Consequently, the author shares a conclusion Helmer and Rescher (1959), 51) have drawn more than half a century ago:

"*As for predictions in the inexact sciences (physical as well as social), these can be pragmatically acceptabel (that is, as a basis for actions) when based on methodologically even less sophisticated grounds that are explanations, such as expert judgement* (≈ plausibility, Hofmann), *for example.*"

It seems relatively easy to transfer the majority of arguments given in this article from the military domain to other kinds of social simulation.

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